

Antarctic Ultraviolet Radiation Climatology from Total Ozone Mapping Spectrometer Data

Dan Lubin

Scripps Institution of Oceanography
UCSD, 9500 Gilman Drive
La Jolla, CA 92093-0221

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This project has successfully produced a climatology of local noon spectral surface irradiance covering the Antarctic continent and the Southern Ocean, the spectral interval 290-700 nm (UV-A, UV-B, and photosynthetically active radiation, PAR), and the entire sunlit part of the year for November 1979-December 1999. Total Ozone Mapping Spectrometer (TOMS) data were used to specify column ozone abundance and UV-A (360- or 380-nm) reflectivity, and passive microwave (MW) sea ice concentrations were used to specify the surface albedo over the Southern Ocean. For this latter task, sea ice concentration retrievals from the Nimbus-7 Scanning Multichannel Microwave Radiometer (SMMR) and its successor, the Defense Meteorological Satellite Program (DMSP) Special Sensor Microwave Imager (SSM/I) were identified with ultraviolet/visible-wavelength albedos based on an empirical TOMS/MW parameterization developed for this purpose (Lubin and Morrow, 2001). The satellite retrievals of surface albedo and UV-A reflectivity were used in a delta-Eddington radiative transfer model to estimate cloud effective optical depth. These optical depth estimates were then used along with the total ozone and surface albedo to calculate the downwelling spectral UV and PAR irradiance at the surface. These spectral irradiance maps were produced for every usable day of TOMS data between 1979-1999 (every other day early in the TOMS program, daily later on).

A preliminary version of this satellite UV retrieval method for Antarctica, which could handle sea ice concentrations only up to 50%, was used for the ecological study published by Arrigo et al. (2003), which considered the differential UV-B impact on primary production between 1992 (a deep ozone "hole" year) and 1979 (control). Subsequently, the improved method based on the sea ice albedo parameterization of Lubin and Morrow (2001) was used to generate the entire 20-year climatology. This climatology was analyzed to determine when and where enhanced UV-B due to the springtime ozone depletion intersects significant concentrations of phytoplankton as determined from NASA's SeaWiFS program. This study found that (1) significant UV-B enhancements over phytoplankton biomass began only 2-3 years prior to the (1985) discovery of the ozone "hole" and hence several years before dedicated biological field work began, and (2) the Weddell Sea and Indian Ocean sectors of the Southern Ocean are subject to the greatest enhancements in UV-B over phytoplankton biomass. These results were published by Lubin et al. (2004). The relative impacts of multidecadal trends in cloud opacity and sea ice concentration, versus trends in ozone, are discussed by Lubin (2004). These considerations are important given the spectral dependence in the biological weighting function for photoinhibition in Antarctic phytoplankton, which

contains a significant (ozone-invariant) UV-A component that reduces the role of ozone variability relative to other environmental factors.

Publications Resulting from this Work:

- Arrigo, K., D. Lubin, G. L. van Dijken, O. Holm-Hansen, and E. Morrow, 2003: The impact of a deep ozone hole on Southern Ocean primary production, *Journal of Geophysical Research - Oceans*, **108**, doi: 10.1029/2001JC001226.
- Lubin, D., 2004: Ultraviolet radiation environment of Antarctica, II. trends in environmental factors. *Journal of Geophysical Research-Atmospheres*, in preparation.
- Lubin, D., and E. Morrow, 2001: Ultraviolet radiation environment of Antarctica: I. effect of sea-ice on the top-of-atmosphere albedo and on satellite retrievals, *Journal of Geophysical Research-Atmospheres*, **106**, 33,453-33,462.
- Lubin, D., K. Arrigo, and G. L. van Dijken, 2004: Increased exposure of Southern Ocean phytoplankton to ultraviolet radiation. *Geophysical Research Letters*, **31**, doi:10.1029/2004GL019633.